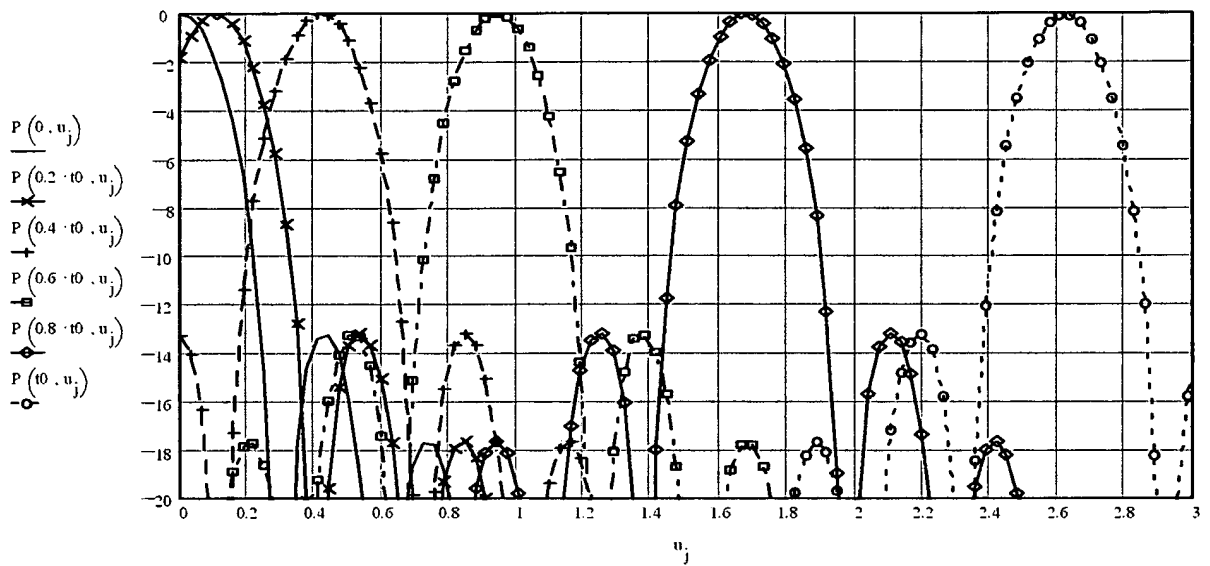


[23] Nicodimus Retdian, Shigetaka Takagi, Nobuo Fujii, "Voltage Controlled Ring Oscillator with Wide Tuning Range and Fast Voltage Swing", <http://www.ap-asic.org/2002/proceedings/4A/4A-5.PDF>

[24] U.S. Pat. Application No. 20,020,175,859, entitled PHASED ARRAY ANTENNA SYSTEM

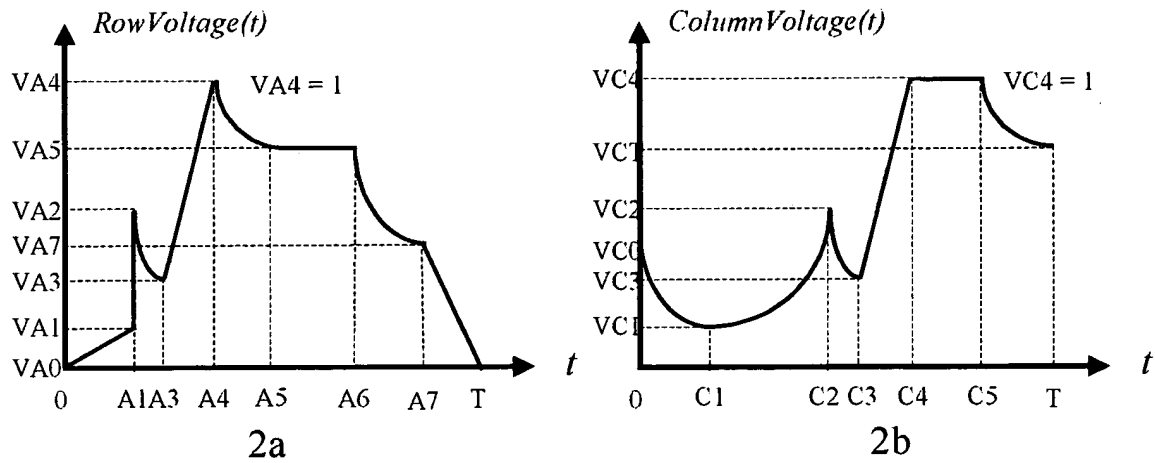
5 WITH VIRTUAL TIME DELAY BEAM STEERING, filed November 28, 2002, by Newberg, et al.



$$VoltageColumn(t) = \begin{cases} t/t0 & \text{if } t \leq t0 \\ t0/t & \text{if } t0 < t \leq \tau \end{cases} \quad \tau = 10^{-6} \text{ sec}, \quad t0 = 0.25 \cdot \tau, \quad u_j = (2\pi f_0 / c) \cdot d \cdot \sin \theta_j$$

τ is the pulse duration, $f_0 = 3 \text{ GHz}$, and d is 50 mm.

Fig. 1



$$\sin(\theta(t)) \cong t \sqrt{(RowVoltage(t))^2 + (ColumnVoltage(t))^2}$$

$$\tan(\phi(t)) = \frac{ColumnVoltage(t)}{RowVoltage(t)}$$

Fig. 2

$$RowVoltage(t) = \frac{\sin(\theta(t)) * \cos(\phi(t))}{t}$$

$$ColumnVoltage(t) = \frac{\sin(\theta(t)) * \sin(\phi(t))}{t}$$

Fig. 3

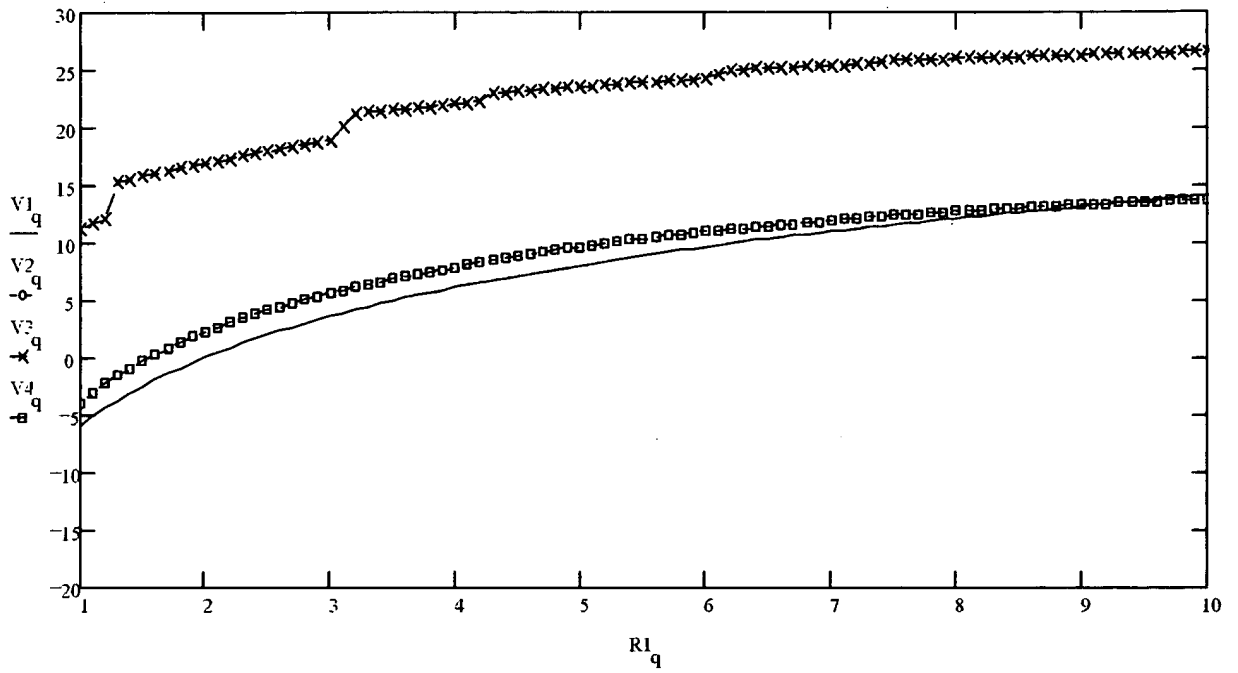


Fig. 4

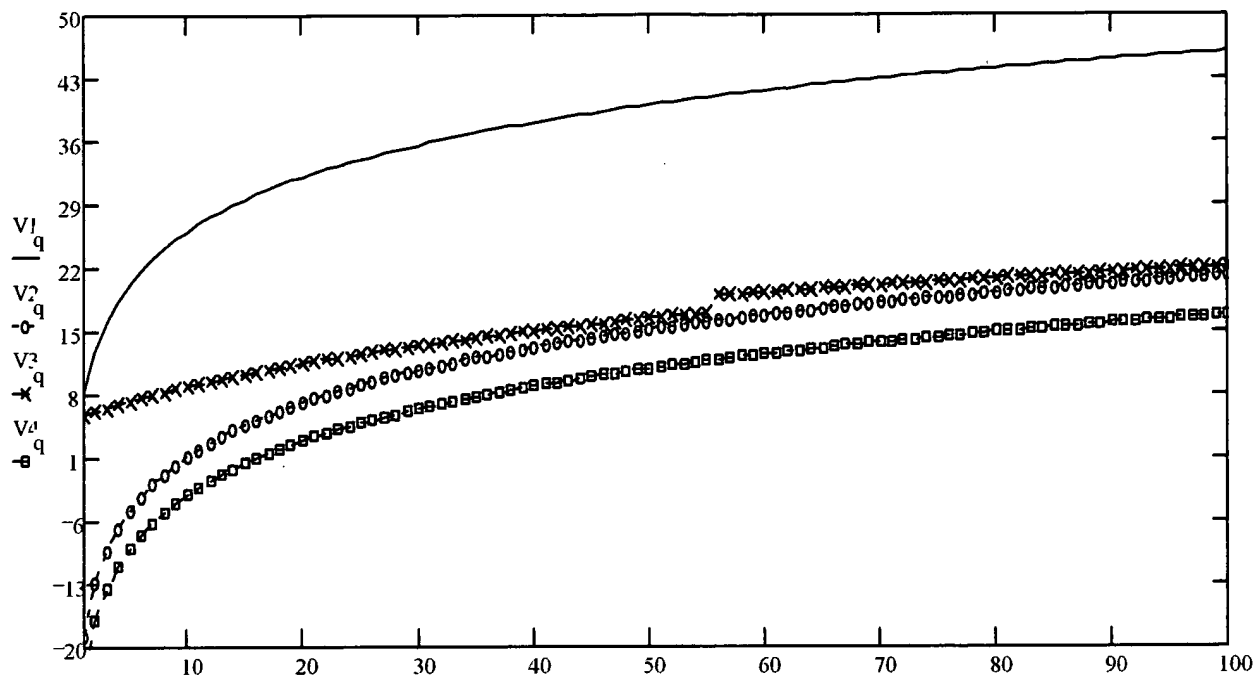


Fig. 5

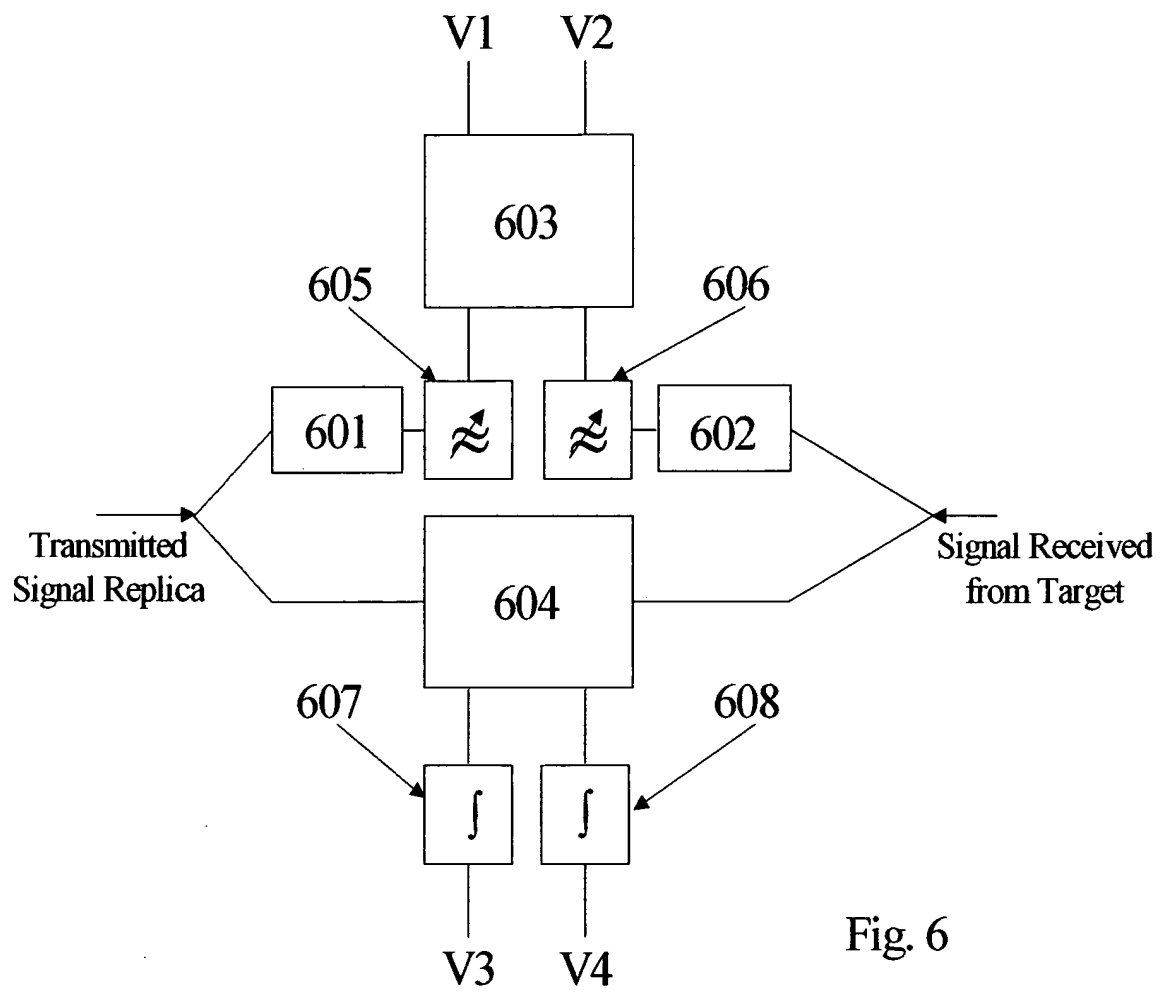


Fig. 6

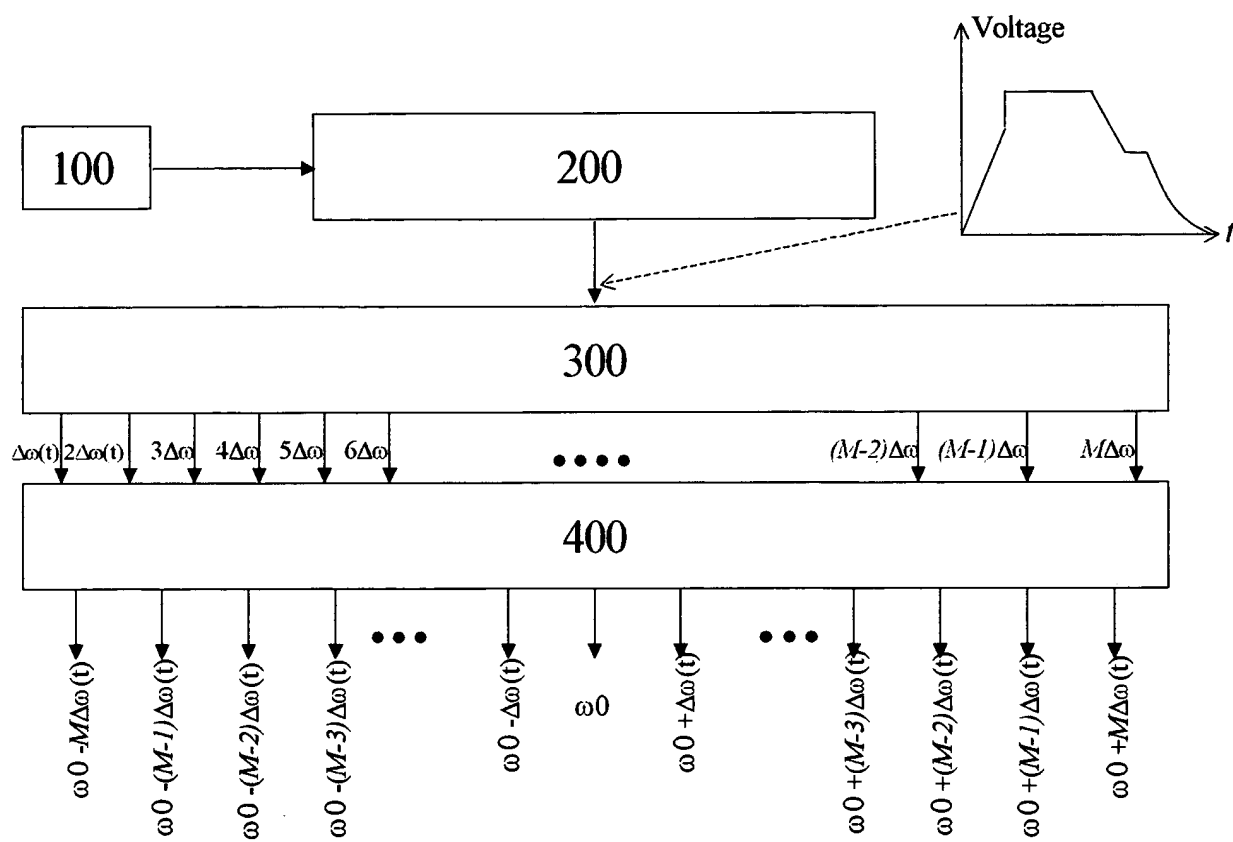


Fig. 7

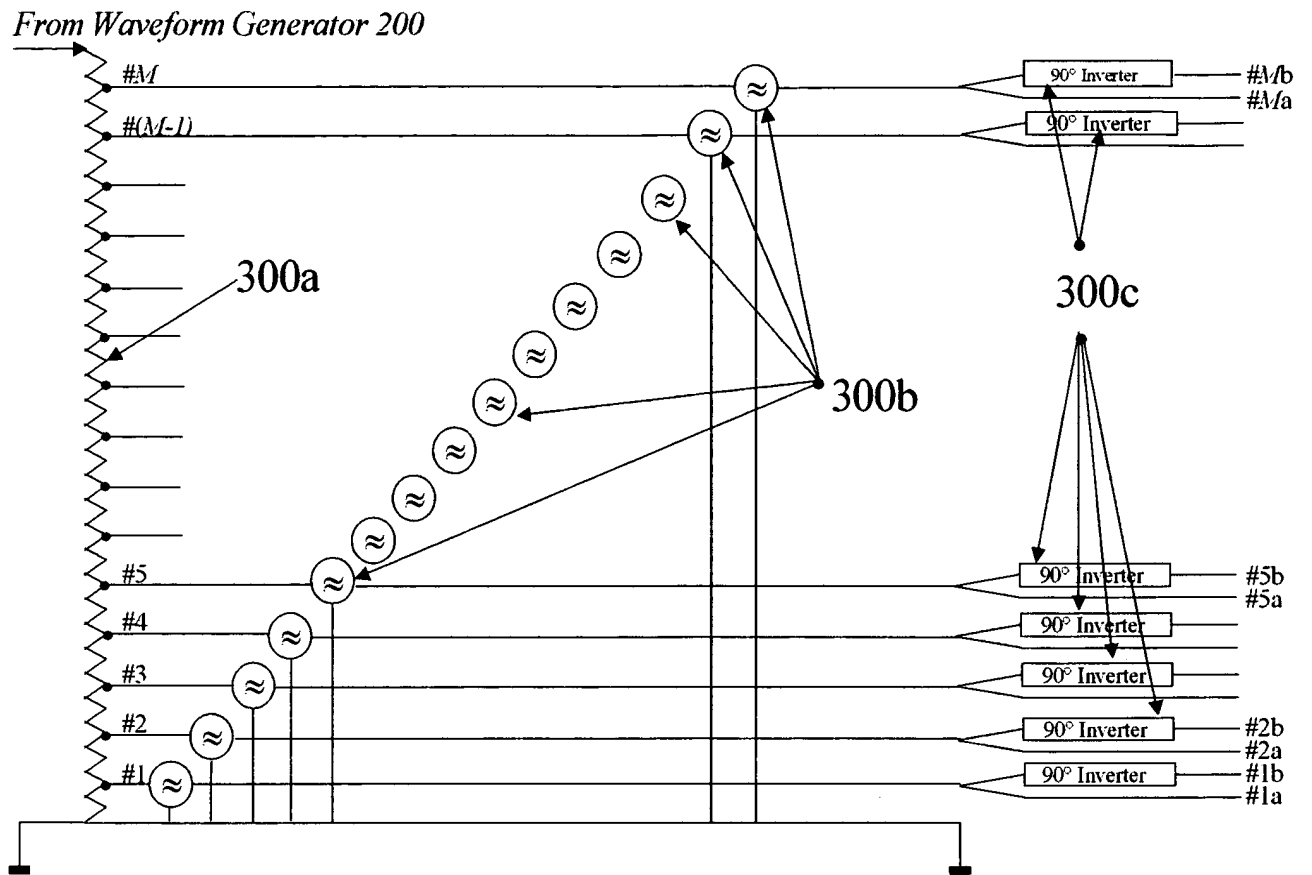


Fig. 8

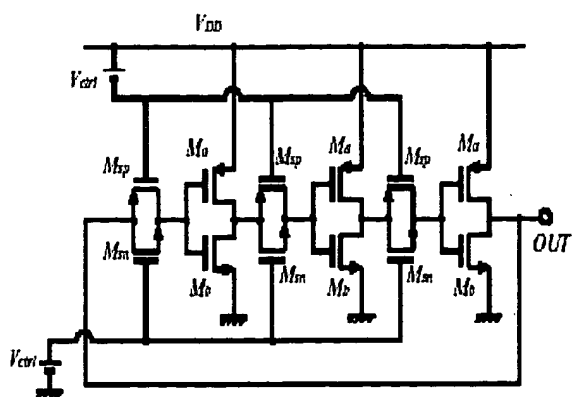


Fig. 9a

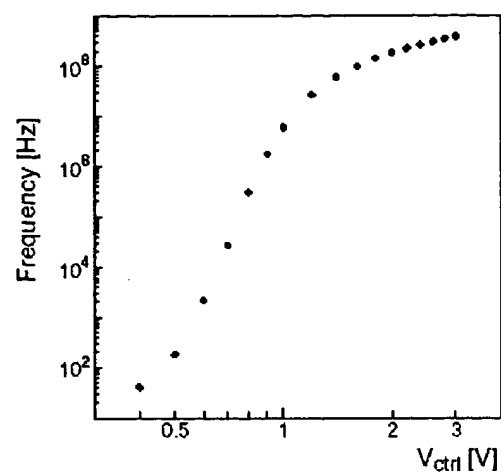


Fig. 9b

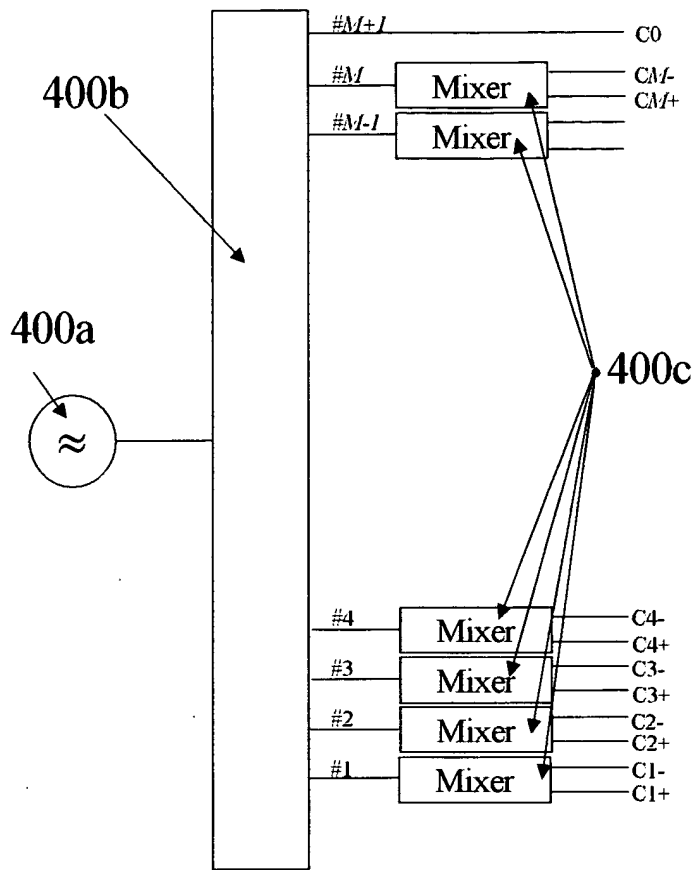


Fig.10

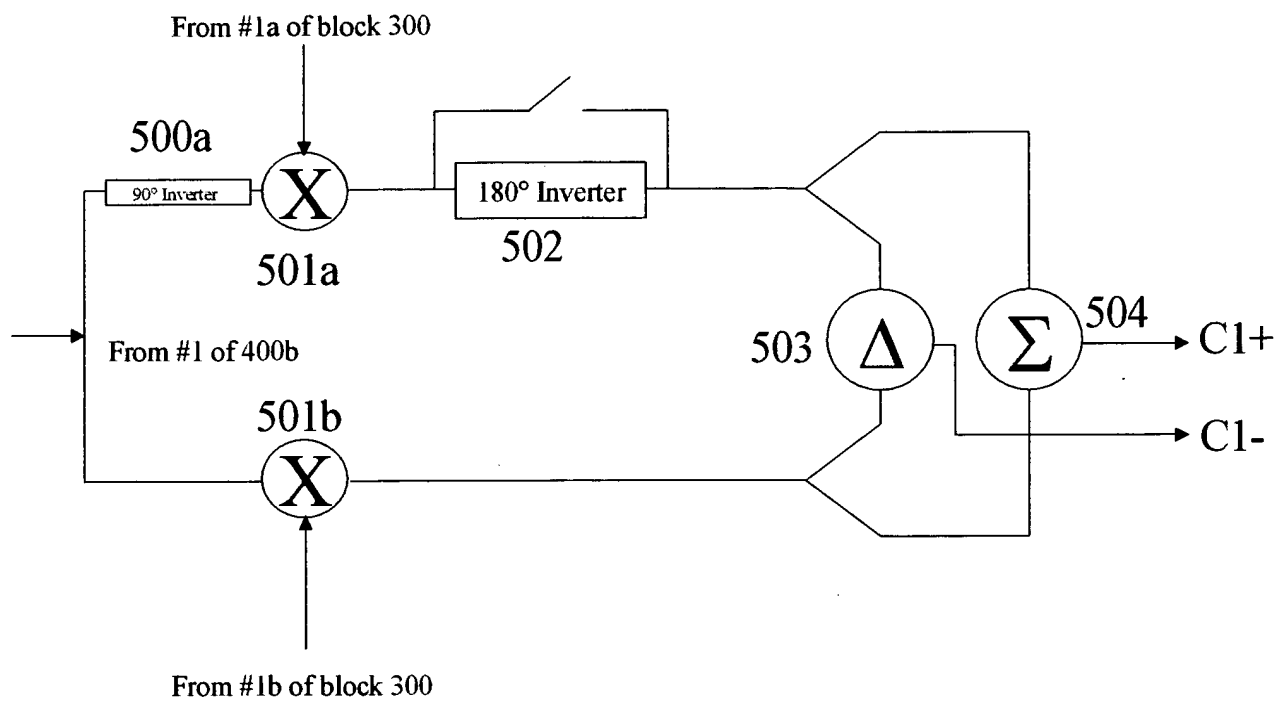


Fig. 11

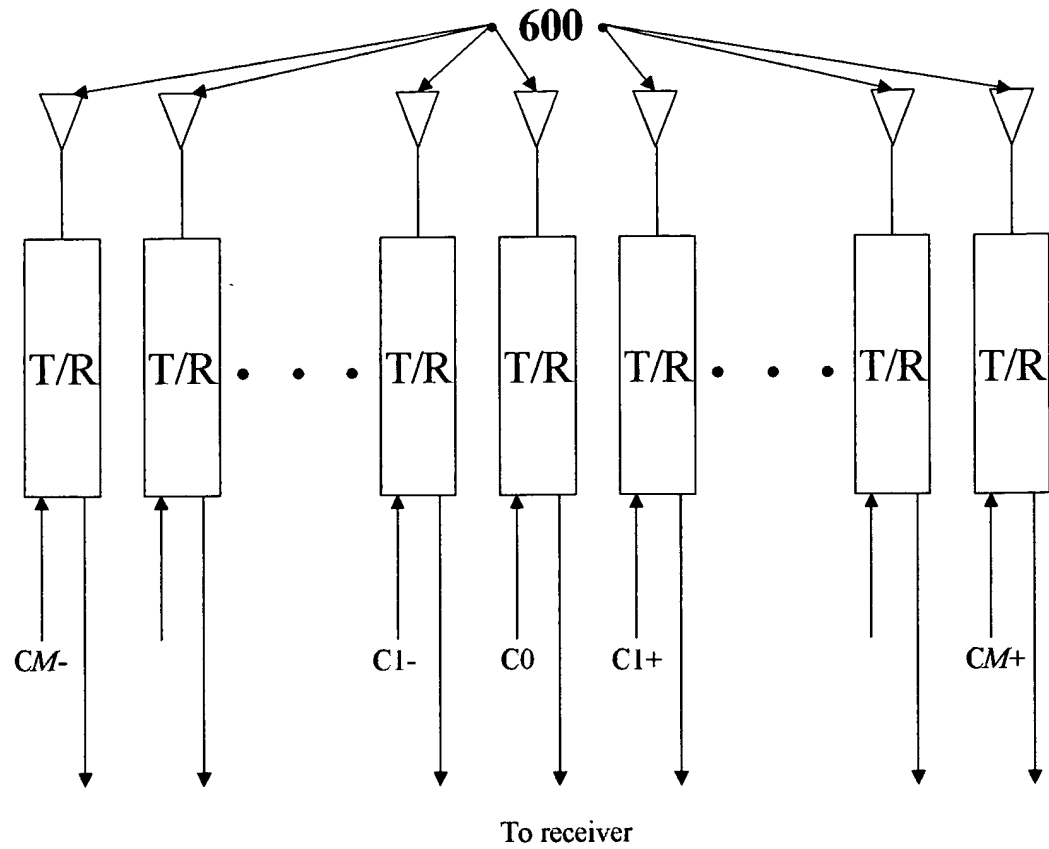


Fig. 12